Agro-management Approaches for the Sustainability of the Biodiversity of Ancient Olive Orchards in Palestine

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Abstract: Ancient Olive Orchards (AOOs) occupy most of the Palestinian lands and represent a vital cultural heritage. This study is aimed at assessing the impact of different farming systems on flora biodiversity. Fields with two different farming systems (organic-registered and traditional-managed) were subjected to soil fertility, biodiversity indices, and a socio-economic analysis between the years 2017-2018. The results showed a higher percentage (1.74%) of total organic matter in the organic-registered fields. Biodiversity indices (Shannon diversity index (H`) and Margalef's index (D)) recorded higher values as well (3.27; 10.12, respectively), reflecting the impact of agricultural practices on wild diversity. The same was noted in ecological infrastructures where 330 different species in forty-eight families were identified. Even so, both farming systems were insignificantly different; and that might be attributed to the similarity of practices between them in Palestine. From a socioeconomic point of view, these practices are of a low cost and are economically wise while adding quality to the products. In Misilyah, AOOs were found to harbor plant biodiversity in synergic harmony. Thus, applying organic farming practices is recommended as the best socio-economic approach for biodiversity sustainability. Such practices are also potentially profitable through eco-tourism and are symbolic and representative of the national heritage of this area. Also, they can provide an additional source of income for the people of this area.

Keywords: Biodiversity; Ancient olive; Conservation; *Flora Palestina*; Agroecology

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Introduction

The Mediterranean landscape is characterized by the presence of olive trees and olive groves. A large part of olive production in the world is annexed to the Mediterranean area since olive trees are part of the agricultural tradition and historical events of the people (Dessane, 2003). Also, olive oil has the most economical value in the marketing chain of many Mediterranean countries; therefore, it has a high economic and social impact.

Olive orchards are also considered a habitat for many plant and animal species (Perrino *et al*., 2011; Biondi *et al*., 2007), which means that the Mediterranean region is unique for its widespread and ancient olive orchards (AOOs). In fact, it can be easily concluded that olive agroecosystems are about 2.800 years old (Zohary, l973) and thus, are high in biodiversity.

Agricultural practices are closely related to the biodiversity of wild flora and fauna communities. More than any other human activity, agriculture is impartibly linked to biodiversity benefiting, modifying, and even contributing to its maintenance (Barberi *et al*., 2010; Chapin *et al.,* 2000; Wood and Lenné; 1997).

The role of agricultural systems in biodiversity conservation is complex going in both directions being both a source for biodiversity and a threat to it (Rey Benayas and Bullock, 2012). Farmers may economically benefit from the intensive use of land, but the costs paid by societies are high (pollution of water by pesticides, leaching of excess nutrients, habitat loss for native species. Thus, the total or social economic value of agro-biodiversity must include the value of ecological services that it can provide (Jackson *et al*., 2007). Organic farming is expected to sustain soil, ecosystems, and people. Combining tradition, innovation and science might promote fair relations and a good quality of life for all those involved.

Olives in Palestine date back to 4,000 years ago, and are considered among the most important crops (Basheer-Salimia *et al*., 2009) covering about 51% of the total cultivated area (Basheer-Salimia and Ward, 2014). This study is aimed at assessing the impact of agro-management practices (organic and conventional) on plant diversity in ancient olive orchards and checking for any putative conservation actions.

Materials and Methods

Field selection criteria

Fields were selected based on the number of ancient olive trees, area, and management system (traditional or organic farming). Several olive orchards in the northern part of the West Bank were visited and investigated for their olive trees age and size during the period 2016-2017. Olive trunk diameters were the main criteria in determining the oldness of trees. Trunk circumference was measured at the height of 130 cm from the base of the tree for that purpose.

Fields of more than one hectare in size; and with more than 60% of its olive trees being ancient, were chosen for this study. The selected ancient olive orchards were visited several times between December and April over the period from 2017 to 2018 to report the farming practices. The first survey was conducted in April 2017; the second was in July 2017 and the third was in April 2018.

Soil fertility

Soil was analyzed at the National Agricultural Research Center (NARC) labs according to the International Centre for Agriculture Research in Dry Areas (ICARDA) soil analysis procedures. Briefly, three samples from each field were collected at the depth of 30 cm, and were mixed and left to dry in the open air. Soil organic matter (Organic carbon) was determined by the rapid oxidation method (ICARDA, 2001). Soil soluble salts were prepared from 100 g of air-dried soil in 100 ml of distilled water. The solution was shaken for thirty minutes in the rotating shaker, and was filtered and Na^+ and K^+, ions were determined using Flame photometry, while titration was used for measuring Mg^{2+}, Ca^{2+} and Cl^-. The Kjeldahl method was applied for determining nitrogen in organic substances as total Kjeldahl Nitrogen (TKN), while the Olsen Method measured phosphorus.

Assessment of biodiversity in ancient olive orchards

Biodiversity assessment in the selected six fields was carried over three different periods between 2017 and 2018. The first one was in April 2017 and is referred to as (T1); the second was in July 2017 (T2); and the last one was in April 2018 (T3). Sampling of the floristic components included both cultivated plots and ecological infrastructures. At the end of the surveys, a list of all plant species with their corresponding families were developed, and the threatened species were highlighted. The simplified Raunkiaer method (Cappelletti, 1976) was applied to the cultivated plots for categorizing the biodiversity of herbaceous species. It was applied at a fixed number (9 to 10) per plot, using a square metal frame (point quadrats) of an agreed side of 0.25 m. The systemic sampling method with diagonals of 4-5 throws was used in the ancient olive groves where the ground cover was not uniform.

The diversity indices were calculated using the Species Richness (S), Shannon diversity index (H`), and Shannon's equitability (E_H) or (evenness) to provide information not simply about species numbers, but also about community composition (Shannon, 1949).

The species richness (S) which reflects

the number of existing species within the studied area was achieved by counting the identified species in these fields. Local and international botanical experts in plant taxonomy and classification were consulted, and a taxonomical identification software available online was used for further verifications. Threatened species were expected according to experts and local community observations.

The Shannon diversity index (H`) was then calculated using Shannon and Weaver formula:

$$H' = -\sum_{i-1} pi \times lnp_i$$

Where S is the total number of species in the community, and *P*i is the proportion of S made up of the i^{th} species.
Besides, data analysis were applied to assess the degree of distribution existing in the field's diversity using Shannon Equitability Index (E_H) following this formula:

$$E_H = H'/H_{MAX}$$

Where H_{max} = ln S (Equitability values assumed to be between 0 and 1, where 1 signifies a field of complete evenness). In addition, the Margalef's index (D) for measuring species richness related to sample size was calculated following this formula:

$$D = \frac{n-1}{ln N}$$

Where (n) is the number of species, and (N) stands for the total number of individuals
Ecological infrastructures were also surveyed, and their biodiversity indices were estimated according to the Braun-Blanquet (BB) (1932) method based on the observation of the tested areas with a minimum size of 50 m^2. BB method is usually applied for the assessment of agricultural areas. The surveys were conducted by walking along the subunits, reporting all species found there and assessing the percentage of coverage for each species, considering the code values of Braun – Blanquet Code as in Table 1. After assessing the percentage of the coverage for each layer, the assessment of the species composition inside the layers was summed up.

Statistical data analysis

The data were analyzed by one-way ANOVA at ($p<0.05$). The software package from Simple Interactive Statistical Analysis was used.

Results

Properties of selected ancient olive orchards

Fields surveys were conducted early during the year of 2017 and ancient olive orchards (AOOs) were allocated. Ancient olive trees were determined based on trunk size (> 1m

Table 1: The Braun – Blanquet Code and biodiversity values for each species coverage class. The species coverage was coded from (5:high coverage to 1: (less than 5% coverage). The (+) was given to scarce species coverage, while (r) was used for those with very few individuals (Braun-Blanquet, 1932).

Coverage (%)	Braun – Blanquet Code	Biodiversity values
Species coverage 80 – 100	5	1
Species coverage 60 – 80	4	2
Species coverage 40 – 60	3	3
Species coverage 20 – 40	2	4
Species coverage 1 – 20	1	5
Negligible cover Species coverage < 1	+	6
Very rare species, presenting only isolated individuals	R	7

at height of 130 cm) (Figure1). The selected orchards are located in Misilyah (32° 23.21907’N 35° 17.28221’ E) in the Jenin province in the northern part of the West Bank-Palestine.

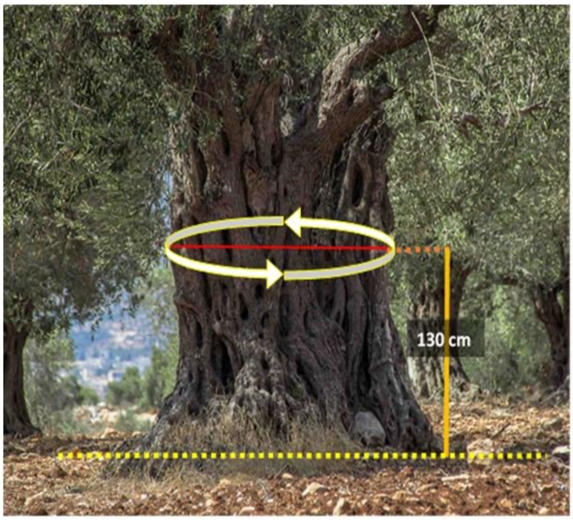

Figure 1. An ancient olive tree which was determined by measuring its trunk diameter at the height of 130 cm of tree base in olive orchards (left);aerial view of the selected olive orchards located in Misilyah (right).

The selected fields were irregularly planted with > 50 ancient olive trees per hectare. No intercropping plants were noticed except for a few ignored almond trees. The selected fields were categorized based on their farming managements: organically certified fields and traditionally farmed ones. Fields (*No.*1, 2, 3) were those converted to organic since 2014 and are certified by the Institute for Market ecology (IMO), an international organic certification body, while fields (*No.* 4, 5, 6) were considered as traditionally farmed ones (Figure1).

The organically certified fields AOOs apply biodiversity-eco-friendly farming methods such as the mechanical control of herbs (shredding tools and /or minimum tillage), and use organic fertilizers (manure/compost) instead of chemicals in addition to leaving shrubs and natural growing plants among their olive trees and field borders (Ecological infrastructure) undisturbed.

Both organic and conventional/ traditional farming approaches were reported to have common agricultural practices such as plowing, pruning and the application of manure as fertilizers. In general, all fields tend to plow the soil two-three times during the year that is in November, February, and at the end of March, depending on the weather and the vegetation growth. The main tool used by farmers in these fields was the chisel plow which loosens the soil surface to the depth of 8-10 cm to control weeds and increases soil’s water-holding capacity. Moreover, the use of herbicides was reported in the conventional fields several times during the year, and animal grazing was also noticed several times during the research study period.

Impact assessments of farming practices on soil fertility

The soil samples were tested to detect any variations in soil chemical composition between organic and conventional fields. The results showed that the total organic matter as well as trace elements were higher in the organic fields than in the conventional ones (Table 2).

Table 2. Soil chemical analysis.

Test	Organic managed fields			Conventional managed fields		
	*No.*1	*No.*2	*No.*3	*No.*4	*No.*5	*No.*6
Organic Matter %	1.75	1.74	1.72	1.51	1.67	1.69
NO_3 (ppm)	3.18	6.63	2.95	2.56	4.02	2.74
P_2O (ppm)	4.14	4.04	3.23	2.12	2.63	2.83
Ca (ppm)	50.1	90.2	50.1	50.1	74.1	58.11
Mg (ppm)	24.3	24.3	18.2	18.2	18.2	8.5
Na (ppm)	12	6	6	10	12	9
K (ppm)	9	9	6	9	10	7

However, no significant differences were found in the soil analysis between the organic and conventional fields. More soil analyses with large sample sizes are recommended for a better understanding of the soil fertility and correlation between the organic and conventional ones.

Biodiversity measurements

Fields were surveyed during different sampling periods from 2017 to 2018 in order to reveal any changes in *flora* communities related to agricultural practices. AOOs were found to be in marvelous harmony with nature and reflect the old history of synergism (Figure 2). These fields were traditionally farmed.

The simplified Raunkiaer method of assessment was applied to the cultivated plots and the data were calculated using the Shannon diversity indices (H`; S; and E_H) along with Margalef's index (D). The Braun-Blanquet (BB) method of assessment was applied to check the ecological infrastructure. The results of the three surveys are shown in Table 3.

Figure 2. Ancient olive tree with synergic harmony with wild nature.

Table 3. Biodiversity assessment in all selected fields.

April 2017	H`	S	E_H	D	BB
*No.*1	**3.27**	40	**0.89**	7.68	412
*No.*2	3.18	47	0.83	8.15	306
*No.*3	3.25	47	0.84	8.47	**491**
*No.*4	2.35	56	0.58	8.73	304
*No.*5	2.39	36	0.67	5.91	297
*No.*6	2.94	**64**	0.71	**10.12**	416
July 2017	**H`**	**S**	E_H	**D**	**BB**
*No.*1	**2.26**	**13**	0.88	**3.34**	31
*No.*2	1.26	5	0.78	1.05	34
*No.*3	1.28	4	0.93	0.94	35
*No.*4	0.68	2	**0.98**	0.29	41
*No.*5	1.98	8	0.95	2.3	40
*No.*6	1.63	6	0.91	1.8	**48**
April 2018	**H`**	**S**	E_H	**D**	**BB**
*No.*1	**2.88**	26	**0.88**	5.46	270
*No.*2	2.87	28	0.86	5.9	221
*No.*3	2.56	24	0.81	5.38	**428**
*No.*4	2.25	26	0.69	4.8	200
*No.*5	2.11	23	0.67	4.6	236
*No.*6	2.75	**37**	0.76	**6.26**	346

Using the Shannon diversity index (H`), biodiversity was found to be higher in all surveyed organic fields (Figure 3); the highest biodiversity value was recorded as (3.27) in the April 2017 survey.

The results revealed the negative impact of agricultural practices on biodiversity in the cultivated fields. The lowest H` value was recorded for the conventional-farming Field #4 (0.68) in the July 2017 survey even though the highest number of species (64) was also recorded in the conventional Field #6 in April`s surveys. Indeed, the values of the Shannon species richness (S) and Margalef's index (D), used for measuring the species richness in relation to the sample size, were in accordance.

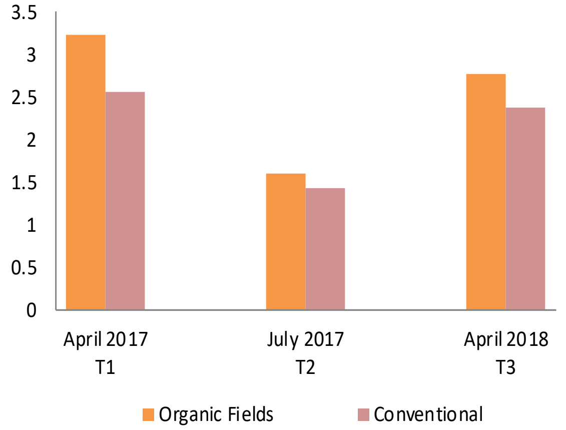

Figure 3. The biodiversity indexes using Shannon diversity index (H`) were higher in organic fields

The lowest species richness was reported in the conventional fields as in Field #4 inspected through the July 2017 survey.

Equitability index (E_H); which expressed the diversity evenness, scored high in the organic fields in April`s surveys; Field #1 (0.89 and 0.88), while the lowest value was recorded for the conventional Field #4 (0.58) in April 2017. Expectedly, conventional fields showed more equitability than the organic ones in the July 2017 survey, with less species and more uniformity.

Ecological infrastructures, which host different species more than the cultivated fields, gave advantages to the margins of organic fields over the conventionally farmed ones in Spring time while in the July survey, they were in favor of the conventional ones based on the Braun-Blanquet modified method (Table 1).

Life form spectra of flora community

The surveys resulted in recording a list of 330 different species which belong to forty-eight families: *Asteraceae* (18%), *Fabaceae* (17%); *Poaceae* (10%), *Apiaceae* (6%), *Lamiaceae* (5%), and *Brassicaceae* (4%). The chorology of the explored species was similar to those characterizing the olive groves underlining the prevailing plant species of the Mediterranean component. These plants were categorized based on their abundance in the area (Table 4) according to the wild plants' checklist (Al-Sheikh, 2019).

Table 4. Abundance of surveyed plant species

Category	No.
Very common -CC	133
Common -C	98
Frequent -F	66
Potentially rare -RP	1
Rare -R	20
Very rare -RR	11
1-3 sits only -O	1
Total	330

A poster indicating the most threatened species was developed (Figure 4). Comparing plant species in the cultivated fields (CF) and ecological infrastructure (EI) can provide further information on the effect of the agricultural practices on the flora.

The plant species classified included (*Therophytes; Phanerophytes; Hemicryptophytes; Geophytes; Chamaephytes*.

Among many others). Comparative studies of their distribution in both cultivated fields (CF) and Ecological Infrastructure (EI) were done in April 2017 and 2018 (Table 5). Except for *Thermophiles*, all other tested classes were found to be covered in the ecological infrastructure more than in the cultivated fields.

The obtained results from life form analysis for the April survey (T1) showed that the main life form in all the cultivated parts of the fields was *Therophytes,* with an average of 91.5%, followed by *Hemicryptophytes* (4.2%).

As for the ecological infrastructure, the main life form was *Therophytes*, which formed 63%; followed by the rich life form of *Hemicryptophytes* that formed 18.8%. The lowest representative life form was *Geophytes* reaching up to 3% on average. When comparing the results with the second survey of April 2018 (T3) it was found that the main common life forms in the cultivated plots were still the same.

Socio-economic value

A questionnaire was developed for reporting the socioeconomic values of the ancient olive orchards and their plant biodiversity in Misilyah. The results showed that ancient olive trees can add value to the village olive industry (oil, fruit, wood, soap ...etc.); and is attractive to eco-tourisms; besides, it is considered as a symbol of the village's national heritage.

The collected data showed that more than two thirds of surveyed participants were aware of the synergism between Olive orchards and wild plants (herbs, shrubs, and trees), as they harbor the beneficial bacteria which provide olives with nutrients. At least 62% agreed that wild plants in the olive fields must be protected by avoiding the use of chemical herbicides and/or excessive deep plowing. The 56% of those surveyed believed that in addition to their importance in nature, wild plants can provide a source of additional income to the farmers. The majority of participants (88%) believed that wild sage, thyme, and many other plant species almost disappeared due to overharvesting and/or excessive use of herbicides.

About 48% of the participants think that ancient olive trees and their ecosystem could provide additional income by encouraging eco-tourism in Misilyah and through the potentiality intercropping systems.

The benefits of ancient olive orchards and their related biodiversity, which will generate additional values and income to the Misilyah village, encouraged the Misilyah local council to contact governmental and non-governmental organizations for the sake of protecting this ecosystem.

More than 60% of the surveyed people believed that biodiversity in the ancient olive fields must be protected, particularly from rural expansion, as mentioned by one third of the surveyed farmers .

Besides, more than 56% of those questioned were convinced of maintaining the biodiversity of the ancient olive orchards for they could be perfect for attracting eco-tourism.

Figure 4. Plant biodiversity photographed in Misilyah showing the most threatened species

Table 5. The average life form in all the fields in T1 and T3 for the plant classes: *Therophytes*; *Phanerophytes*; *Hemicryptophytes*; *Geophytes*; and *Chamaephytes*.

	CF/EI	*Therophytes*	*Phanerophytes*	*Hemicryptophytes*	*Geophytes*	*Chamaephytes*
Average in (T1)	CF	91.5%	0.8%	4.2%	1.5%	2.0%
	EI	63.0%	7.7%	18.8%	3.0%	7.2%
Average in (T3)	CF	91.5%	0.0%	6.5%	1.3%	0.7%
	EI	56.0%	11.7%	19.2%	2.7%	10.3%

Discussion

The Mediterranean basin, which is considered as one of the thirty-six hot spot areas of the world, is characterized by its species richness and also hosts the world's most ancient olive groves (Médail *et al*., 2019; Myers *et al*., 2000; CEPF, 2010, Loumou and Giourga, 2003). Palestine is one of the eastern Mediterranean countries with fields holding olive trees that are hundreds if not thousands of years old (MIFTAH, 2014). The northern part of the West Bank was chosen in this study for the field surveys of AOOs because the majority of olive cultivation is there (Figure 1). The northern olive orchards represent approximately 95.4% of the total area that is cultivated with olive in Palestine and account for about 44% of the whole olive trees in the country (Srouji, 2012). Moreover, there are major groves cultivated according to the organic system comprising about 91% of the total organic olive groves in the West Bank.

The olive-tree trunk diameter was used in recognizing the AOOs. The average diameter reached up to 2 m. in the Misilyah village in the Jenin provinces, the richest place with these ancient olive trees, Furthermore, the Jenin governorate was found to be the highest among other governorates in terms of the total production of olive oil, and its production accounts for 29% of the total production in the West Bank. The estimated average productivity of olive oil was 47 kg/dunum, with an annual total production of 23,947 tons in 2015 (ARIJ, 2015).

A list of 330 taxa belonging to forty-six families have been recorded in this research. This was the first survey of *flora* biodiversity to be conducted in this area. It was hard to cover the whole census of flora community in the olive fields during one season of growth; that is why the survey was extended for two to four years for the sake of collecting new species. The results can be considered as a contribution to a better knowledge about the flora community structure in the olive fields of Jenin and of Palestine as a whole.

Organic farming protects the on-field biodiversity as advised by several researchers (Calabrese et al., 2016). In Palestine, there are no previous surveys or studies conducted to assess the fauna and flora biodiversity in the ancient olive fields as well as the impact of agricultural practices on that. Worse still, there are no previous studies on the morphological characterization of the ancient olive trees and their habitat. The analysis and characterization of the olive grove agro-ecosystems in terms of vegetation biodiversity surprisingly showed that the traditional cultural practices were less harmful to the environment, creating a variety of structural conditions that allow the diversification of plant and animal species thus contributes to the high overall level of biodiversity in AOOs.

Biodiversity indices can be considered as a reflection of the human impact on the ecosystem (Vačkář *et al.,* 2012; Gorrod and Keith 2009). Even though both the organic and conventional practices showed good biodiversity indexes, the calculated indices of biodiversity values from the collected data of the three surveys for the cultivated plots showed advantages of the organic practices over the traditional ones. This might be attributed to the t classical conventional practices of Palestinian farmers which in most cases resemble the organic ones. Also, equitability was higher in the organic fields as herbicides were probably used in the conventional fields. Moreover, grazing was observed in the organic fields which might have enhanced the flora community growth of some species even more.

In all fields, *Therophytes* were the main life form in both of the cultivated parts and the ecological infrastructure. They are the main annual plants that can survive unfavorable seasons in the form of seeds. On the other hand, *Hemicryptophytes* geophytes and *Chamaephytes* were affected by agricultural practices like plowing and are less presented in the cultivated parts of the fields.

The presence of ecological infrastructures was quite important as they were useful to ensure the presence of biodiversity associated with farmlands to contribute to supporting production processes through the supply of environmental services (Pecheur *et al.,* 2020). Ecological infrastructures were found to be quite various, such as hedges, wildflower strips, conservation headland, grass strips, ruder areas, small ponds, dry stone walls, dirt roads, heaps of stones, among others. In addition to that, areas of production were defined also as ecological infrastructures, such as the case of pastures, meadows and fallow lands, which contribute to the conservation of biodiversity of the agro-ecosystem. Field margins were found to be very important in improving the components of biodiversity (*flora* and *fauna*) as seen through the BB values (Table 3).

Finally, there was a lack of knowledge regarding the ancient olive orchards and their characterizations in Palestine as well as the importance of ecological infrastructure in their fields. The fields were found rich in flora biodiversity, and the organic management system showed slightly better results in terms of biodiversity richness. There are no significant differences in the practices of the farmers in the organic and conventional fields during the research period. Even so, herbicides must be forbidden as they are destructive of the flora diversity.

This research study is the first of its kind to be carried in the region; however, more studies are recommended to characterize the ancient olive trees and their habitat to valorize their values as sustainable agro-ecosystem and a symbol of the cultural heritage of the Palestinian ancient olive orchards. Without doubt, the traditional agricultural practices of the farmers are still eco-friendly, yet reporting and improving the traditional practices are highly recommended. Also working with the government and the local communities to protect the ancient olive trees and increase the awareness regarding their values is highly advisable.

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